Australian Government
Civil Aviation Safety Authority

AIRWORTHINESS BULLETIN

AWB 85-024 Issue 2 – 7 March 2019

Piston Engine Exhaust Valve and Valve Guide Distress

An Airworthiness Bulletin is an advisory document that alerts, educates and makes recommendations about airworthiness matters. Recommendations in this bulletin are not mandatory.

1. Effectivity

All spark ignited aviation gasoline (AVGAS) reciprocating engines. The condition identified in this AWB may exist or could develop in any aircraft exposed to the described operational conditions.

Direct Population - Lycoming O-320, O-360 and O-540 series engines or their fuel injected variants installed in Robinson R22 and R44 Helicopter Models located in the northern regions of Australia.

2. Purpose

To advise owners, registered operators, pilots, maintenance organisations and Licensed Aircraft Maintenance Engineers of the increasing incidence of premature exhaust valve and valve guide wear, due to elevated combustion temperatures that will lead to degraded engine performance.

A failure to observe or ignoring adverse indications or unusual behaviour of the engine may result in the situation developing to a point where cracks or large chips can form around the edge of the valve face or cause the valve head to separate from the stem with sudden and complete loss of cylinder compression and partial or complete engine failure.

The content and scope of this document is based on current investigation findings and may be updated as additional information becomes available.

Images of Exhaust Valve Seat Degradation and Valve Chipping

At this time, the airworthiness concern described in this Airworthiness Bulletin is not considered an unsafe condition that would warrant Airworthiness Directive action under Part 39 of the Civil Aviation Safety Regulation 1998.

3. Background

Industry participants are seeing a significant increase in incidence of premature engine cylinder removals due to exhaust valve and valve guide wear, predominantly affecting Heli Mustering operations across the northern regions of Australia.

In several cases cylinder changes have occurred within the first 100 hourly inspection due to pressure readings below 60 psi during cylinder compression testing.

The cause of the premature wear has not been established. At this time, it has not been conclusively determined that changes in the fuel composition is exacerbating or contributing to this airworthiness concern.

A number of engine cylinder/valve examples were sent to the Lycoming laboratory for analysis. Heat stress and dry running guides were confirmed with some valves exhibited evidence of embedded contaminants (for example: silicates).

Lycoming has reviewed their engineering change list including cylinder castings for design or manufacturing changes which may have exacerbated or contributed to the described condition. Whilst manufacturing changes have occurred, cylinder casting blanks and patterns have remained stable over the ensuing period.

Robinson as the Type Certificate (TC) holder for the helicopter and the Federal Aviation Authority (FAA) as the TC issuer for both the airframe and engine have been alerted accordingly, in relation to this airworthiness concern.

Intensive root cause analysis is continuing in order to obtain a clear understanding of all potential causative factors prior to any permanent solutions being recommended.

4. References

CASA AWB 85-023 - Piston Engine Spark Plug Insulator Cracking

CASA AWB 85-025 – R22/R44 Engine Intake Valve and Valve Seat Distress

Robinson Helicopter POH insert – HOT CLIMATE COOL DOWN PROCEDURE

Note: Refer to the latest published revision.

5. Recommendations

A. Operating Procedures and Limitations

Air cooling alone, may be insufficient to adequately cool all cylinder components in some elevated temperature operating environments.

For the above reason, it is critical that all aircraft operational and performance limitations as given in the applicable aircraft Pilot's Operating Handbook (POH) and Engine Operation Manual are strictly observed.

During high ambient air temperature operations ensure that the engine cool-down period is adequate and provides a positive indication of a drop in the CHT with an appropriate margin, if flight operations are to continue. Refer Robinson Helicopter POH insert – "HOT CLIMATE COOL DOWN PROCEDURE" for related information.

Be aware that there is a cumulative effect of elevated temperatures on cylinder assemblies which will degrade the properties of those materials over time. Even a cylinder displaying a moderate CHT, can be suffering accelerated wear. Be mindful that a single probe CHT will not necessarily be indicative of all cylinders, nor represent even and consistent cooling of the entire cylinder assembly. CHT is also not necessarily indicative of actual valve temperatures.

B. Use of Appropriate and Qualified Fuel

The risk to the integrity of AVGAS in relation to being fit for purpose can occur at any point in the supply chain from the point of manufacture to final delivery to the aircraft, thus creating the potential to adversely affect aircraft systems and components.

Fuel suppliers need to verify that all product supplied to the market complies with Defence Standard 91-090 AVGAS and has been manufactured, stored and handled in compliance with Energy Institute 1530 aviation fuel quality system compliant supply chains to control contamination risks. Once the product leaves oil industry bulk storage locations and managed supply chains, testing for potential degradation or contamination is dependent on locally adopted standards and knowledge.

It is therefore of fundamental importance that every responsible organisation involved in AVGAS manufacture, supply, storage, transport, uplift and use has such systems in place in order to assure that the fuel is fully traceable, and is preserved such that it continues to meet the requirements of the appropriate specification and end user purpose, whilst in its custody and/or its control.

The following elements need to be considered and addressed accordingly:

1. The fuel product being received is from an organisation that can demonstrate that all product supplied is compliant with the above referenced Standards.
2. Documents provided by fuel suppliers show the product traceability and integrity of each batch and that these documents are maintained.
3. The design, construction and condition of customer storage and delivery tanks are verified as appropriate. Tanks are effectively identified, segregated and dedicated to maintaining fuel integrity and preventing

cross-contamination. Tanks also need to be water drained on a regular basis to maintain fuel integrity and reduce risk of water carryover to aircraft.

4. Ancillary equipment (filter systems etc.) meet appropriate specifications and are adequately checked and maintained to assure the delivery of clean uncontaminated fuel.
5. Fuel turnover is such that evaporative losses or heat induced degradation is kept to a minimum. Fuel held in tank storage for over 180 days without a receipt or drums over 12 months from fill date should be retested by a recognised laboratory accredited to ISO 17025 for aviation fuel testing.

C. Maintenance Regime

The aircraft and engine manufacturer develop their respective maintenance programs with the objective of providing reliable operation subject to “normal use and service”. These “normal use and service” conditions can be influenced and affected by several factors, such as, frequency of use (hours and cycles), techniques used in engine handling (particularly during starting and cool-down), atmospheric conditions during flight and on the ground, the type of flying being undertaken, adherence to published limitations and maintenance standards.

Where these “normal use and service “conditions vary the owner needs to review the maintenance program to ensure that it is appropriate and not deficient for their operational parameters. This may include the accomplishment of existing maintenance tasks at a reduced threshold or the introduction of additional inspections, checks and maintenance activities to assure appropriate continuing support for the aircraft and installed aeronautical products.

<u>What can be done to maximise cylinder valve and valve guide life</u>

1. Air Induction Systems - Assess engine air induction system for properly sealed Air Box Assembly, Filter and Hoses, in addition to an appropriate clean and replacement regime, based on operating environment to prevent the entry of unfiltered air.
2. Powerplant Cooling System – Assess Cooling Scroll Assembly, Fanwheel Assembly, Oil Cooler, Plenum/Baffle Assemblies for condition and sealing to optimise cooling and prevent localised overheating.
3. Valve and Guide Condition Assessment
    a) Inspection – Concurrently with the accomplishment of the exhaust valve and guide condition check given in Lycoming Service Bulletin No. 388C, inspect for the accumulation of carbon deposits around each intake valve stem, fillet and guide. Refer AWB 85-025 Issue 1 (or subsequent), for additional details.

b) Service limitations – At any time a cylinder is removed from an engine the valves should be inspected in accordance with the instructions given in paragraph 2. a. thru f. of Lycoming Service Bulletin No. 301B (or subsequent).

c) For any valves that require refacing ensure that this is performed to a high precision standard to optimise sealing and heat transfer efficiency between the valve and seat in order to disperse the thermal load on the valve stem and guide.

d) For any valve guides that require reaming of the I.D. to remove deposits, select a reamer of the correct dimensions to remove the minimum amount of material. This will allow the guide to support the valve as much as possible and provide the maximum heat transfer from the valve to the guide.

4. Ensure proper fuel system setup and operation in accordance with the aircraft maintenance manual and engine manufacturers service instructions. Check that the fuel flow rate (lbs/hr) is appropriate.

   - R44/R44II (not Cadet) – min 64.4 lph @ MCP
   - R22 Beta II – min 33 lph @ MCP

   (as per relevant Lycoming Operator's Manuals)

5. Ensure oil type and grade is appropriate for the operating environment. Approved higher viscosity oils should be considered during periods of elevated ambient air temperatures and/or when oil inlet temperature approaches the recommended maximum during operation. However, this needs to be balanced against the cold flow characteristics of the oil which may restrict oil flow to certain components resulting in excessive friction and accelerated wear, particularly early morning engine starts at relatively low OAT during certain periods of the year. For example; using W100 oil in winter and W120 oil during summer.

6. To ensure the engine is operating within recommended limits for normal operation, Lycoming strongly recommends that all engine instrumentation be calibrated annually. All instrumentation for manifold pressure, engine RPM, oil temperature, cylinder head temperature, exhaust gas temperature, and turbine inlet temperature in the aircraft should be included in this annual calibration.

7. Engine Condition Monitoring

   a) Regular Borescope Inspection - Enables timely and direct visual inspection of the combustion chamber, including the valves, cylinder head, cylinder barrel, and piston crown. The borescope permits a quick, inexpensive, unambiguous determination of whether the valves are healthy.

   b) Spectrographic Oil Analysis – The oil in your engine not only lubricates, cleans and cools, it can also provide one of the best tools for monitoring power-plant health.

Oil analysis should be used to complement the existing oil filter inspections. It is not a question of which one is better, since the two look at distinctly different aspects. Both could be considered essential in order to get a complete picture of what's going on inside the engine.
While oil filter inspections are usually the best way to determine if something is coming apart inside the engine, spectrographic oil analysis can be thought of as an early warning system capable of giving advanced notice of certain kinds of incipient problems, often long before they can reach a critical stage.
Exhaust valve guides are made of a high-nickel alloy, so accelerated guide wear will show up in oil analysis as increased nickel.
Lycoming Service Letter L171 refers.

c) Enhanced Engine Monitoring - Many engine-related problems can only be diagnosed while the engine is operating. Once it is in the shop, the opportunity for troubleshooting is gone. Various digital engine monitors are available which provide a way to see what is happening during the engine's combustion process, measuring and recording information about the health of the fuel, ignition, induction, and exhaust systems. These systems can serve as an "early warning" device, pinpointing the location and nature of various types of engine problems (sometimes) long before they show up in other ways. Another use of engine monitoring data is for the identification and correction of poor power-plant management techniques which if left unabated can lead to premature engine wear.
These operational and maintenance efficiency gains can offset the cost of system installation within a relative short period of time.

6. Reporting

Report all instances of premature exhaust valve and guide wear to CASA via the DRS system available on the CASA website. Details of the maintenance history for the engine should be provided in addition to information concerning the method of failure detection, the location and condition of the defective parts.

Where possible, flight ops. parameters should also be reported i.e. OAT, RPM, MAP, CHT, Oil Temp, Est. Fuel Burn (lbs/hr) together with any other information on possible triggers for the reported event. This information will facilitate a detailed review of potential failure causes and contributing factors.

7. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletin should be made via the direct link email address:

AirworthinessBulletin@casa.gov.au

or in writing, to:

Airworthiness and Engineering Branch
Aviation Group
Civil Aviation Safety Authority
GPO Box 2005, Canberra, ACT, 2601